bilities: milk, 2 grams per quart; butter, 2 grams per pound; cream, 1 gram per pint; oysters, 4.5 grams per pint; corned beef, 18 grams per pound; ham, 18 grams per pound; sausages, 4 grams per pound. An oyster stew made with a pint of such milk and a quarter of a pint of such oysters, followed by a quarter of a pound of such ham or corned beef, would constitute a not extraordinarily hearty meal for an average man, who would ingest therewith upward of 7 grams of borax and boric acid, an amount which in the course of a day's food might easily be doubled.

INHALATION OF GASOLENE VAPORS.

By Torald Sollmann, M.D.,
OF CLEVELAND, OHIO.

(From the Pharmacological Laboratory of Western Reserve Medical College, Cleveland, Ohio.)

Some years ago (1897) I began an investigation of the effects of gasolene vapors, with a view to finding a cheap anæsthetic for laboratory work. The results showed that this drug would not be practical, and I have delayed their publication on this account. The renewed interest in the subject, aroused by the employment of petroleum ether in Schleich's inhalation mixture, causes me to submit a brief summary of my work. I employed the commercial gasolene in most of the experiments; in a few I used a purer sample of petroleum ether. The effects were identical. These coal-oil products consist of a mixture of various hydrocarbons of the series CnH_{2n+2} and CnH_2n, the principal ingredient being pentan (C_5H_{12}). The experiments were confined to dogs and frogs.

Effect on Normal Dogs. When the gasolene is poured on cotton, applied to the mouth of a dog, and covered with a towel, the very first effect is a deepening of the respiration. The animal then struggles violently to escape, but the movements soon lose their purposive type, and degenerate (within two to ten minutes) into inco-ordinated convulsions. The animal has apparently lost consciousness, and may be laid on the table. The four legs paw the air as in running. The eyelids, the tail, and the toes twitch. The pupils dilate widely. These rather weak convulsions then assume a stronger and more general type, clonic spasms alternating with tetanus. The neck muscles develop a surprising strength. During this convulsive stage the animal appears quite insensitive to pain, but the corneal reflex is not quite abolished. In the intervals between the general convulsions the animal lies flat, apparently exhausted, with constant twitching of individual muscles.

Death occurs suddenly in two to twenty minutes, heart and respiration stopping at nearly the same time.

The general course of the intoxication was very uniformly, as described, in four normal dogs. In a fifth animal, however, in which death occurred in seven minutes, the convulsions were more of the ordinary asphyxial type.

The autopsy of the animals killed by the inhalation of gasolene gave also very uniform results. The veins and the heart, especially the right side, are considerably distended. The lungs and skeletal muscles are conspicuously pale; the kidneys are injected. The liver, spleen, and intestines appear normal. The blood remains fluid for some time after death. It does not show any striking microscopic or spectroscopic changes.

The previous injection of a heavy dose of morphine does not modify the phenomena if the gasolene is pushed (one experiment); but it makes it possible to graduate the effects and to extend the inhalation over some time.

An experiment made in this manner showed that even a dilution of 1:5 causes some anæsthesia and some convulsions. The anæsthesia was not, however, very deep. Recovery followed promptly on discontinuing the administration. The protocol of this experiment follows:

Experiment. At 10.59 began the administration of 1 volume petroleum ether to 5 volumes of alcohol.

In three minutes there are convulsions, pupils large, some anæsthesia, cornea sensitive.

Discontinued gasolene and started artificial respiration.

In one minute the animal raises its head, and in two minutes it walks around.

At 11.06 administered petroleum ether 1 to alcohol 1.

In twenty-eight minutes twitching of eyelids and lips, tongue blue, general convulsions, pupils rather large, very little anæsthesia.

Artificial respiration begun. The pupils become normal long before the twitchings disappear. In six minutes the animal is still weakly anæsthetic; in eleven minutes it runs about, but is very narcotic.

Effect of the Inhalation of Gasolene on the Circulation and Respiration. For this purpose the animals were first put under a preliminary anæsthesia by a heavy dose of morphine and sufficient A. C. E. mixture. A carotid artery was connected with a kymograph. The trachea was supplied with a cannula, and this was connected with a T-piece, one end of which led to a Woulfe's bottle containing the anæsthetic (or gasolene); the other end leading to a Marey's tambour which registered the respiratory movements. The experiments were made on four dogs.

Mixture of Gasolene 1 *to Alcohol* 8 (*volumes*). The animal remained perfectly anæsthetized for two hours without noticeable change in the blood pressure. At this time the characteristic convulsions set in. The A. C. E. mixture was substituted, and the convulsions disappeared.

Gasolene 1 *to Alcohol* 5. No effect in fifteen minutes beyond a slight slowing of the heart.

Gasolene 1 *to Alcohol* 3. Immediate weakening of the heart, with fall of the mean blood pressure. Respiration greatly deepened and somewhat slowed.

Undiluted Gasolene. Three experiments showed an immediate weakening and quickening of the heart, with corresponding fall of blood pressure. Section of the vagi in the one experiment in which it was tried did not cause further quickening. The respirations were increased in depth and frequency. One animal died suddenly in ten minutes; the second died in thirty minutes, death being preceded by a sudden fall of blood pressure. The third animal survived over one hour, when it was killed by asphyxia. The last two animals showed a number of the typical convulsions, occurring first respectively three and seven minutes after beginning the administration. During the spasm the heart force increased somewhat, and the blood pressure rose greatly. In the intervals between the convulsions the blood pressure showed a further fall, and muscular twitchings persisted.

It is seen that dilutions of 1:5 are practically devoid of any effect on the circulation. The convulsions occur late. Some degree of anæsthesia can be maintained. With greater concentrations the phenomena consist in an increase of respiration (especially depth) and in a fall of blood pressure. The latter is at least partly attributable to a weakening of the heart. The tonic vagus inhibition is depressed or abolished. The convulsions cause a considerable vasomotor stimulation. Death occurs through vasomotor paralysis (with respiratory failure?), but is very late in some cases.

Effect of the Anæsthetics on the Convulsions. The preceding protocols show that the convulsions can occur after A. C. E. anæsthesia. I have, however, three records in which the convulsions were absent. In one of these asphyxia also did not produce convulsions. It may therefore be assumed that the absence of the convulsions in these cases was due to the persistence of the A. C. E. anæsthesia, which, as we know, lessens the effects of many convulsant poisons.

Effect on Frogs. Three experiments were made. The animals were placed under a bell-jar, the air of which was kept saturated with the vapor by a wad of cotton impregnated with the fluid.

Commercial gasolene was used in the first two experiments. The effects were uniform. The animals at once became excited, tried to escape, wiped the nose with the forepaw, etc. Soon paralytic phenomena were noticed, and in two and one-half to four minutes the animals could not turn when placed on the back, although they made ineffectual attempts. When put in water they could not maintain their position, floating with head upward. They would make an occasional fairly powerful stroke, but turn on their side in doing so. Replaced in the jar they would sit flat and execute occasional swallowing movements. In ten to fifteen minutes they would lie flaccid, with legs extended, but react weakly to stimulation. This excitability was also gradually lost, and the animals appeared dead, but on exposing the heart it was still beating strongly. The third frog was treated with petroleum ether, and the same phenomena developed, but more slowly. None of the animals exhibited any convulsions.

Results of Other Investigators. The older literature of gasolene inhalation is summarized by Joseph.[1] The first two cases were of laborers poisoned in cleaning gasolene tanks. The effects were doubtless in large part asphyxial. Some animal experiments of Felix are quoted. Some experiments were also made on criminals, in whom complete anæsthesia was produced.

Elfstrandt[2] investigated pure pentan. The effects on frogs, rabbits, and cats agree with those reported by me. Death occurred by paralysis of respiration, and complete recovery resulted on artificial respiration. The anæsthetic action is comparatively weak. The blood pressure in rabbits is lowered to a greater extent than by ether anæsthetic.

Meltzer[3] notes the convulsions, but saw no anæsthetic effect. With the latter conclusion I must disagree.

Kochmann[4] ascribes to petroleum ether a very weak anæsthetic action.

CONCLUSIONS. Gasolene (or petroleum ether) when inhaled has a comparatively slight anæsthetic action. The anæsthesia is, however, very dangerous, since the substance also produces convulsions, weakening of the heart, vasomotor depression, and paralysis of respiration. The kidneys are also irritated. The effects are produced very promptly, and recovery under artificial respiration is also prompt.

The cause of the convulsions is not known. They do not occur in frogs.

---

[1] C. Joseph. Inaugural Dissertation, Leipzig, 1896.

[2] M. Elfstrandt. Arch. f. exp. Path. and Pharm., 1900, Bd. xliii. p. 435.

[3] S. J. Meltzer, 1898. Cited by W. Meyer, Journal of the American Medical Association, 1903, vol. xl. p. 555.

[4] M. Kochmann. Arch. intern. de pharmacodyn. et therap., 1903, vol. x. p. 347.